International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

CIE Stakeholder Workshop for Temporal Light Modulation Standards for Lighting Systems

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NRC · CNRC

Credits

- Organizing Committee
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- Acknowledgements
  The CIE thanks the sponsors of the workshop for their financial assistance and support: Natural Resources Canada – Office of Energy Efficiency; National Electrical Manufacturers' Association; Philips Lighting; BC Hydro, and the National Research Council of Canada.

Many types of organizations active on TLM

International standards
Phenomena, metrics, visibility limits, test methods & test equipment

Regional standards
Application dependent acceptability limits, compatibility specifications

Regulation
Market access

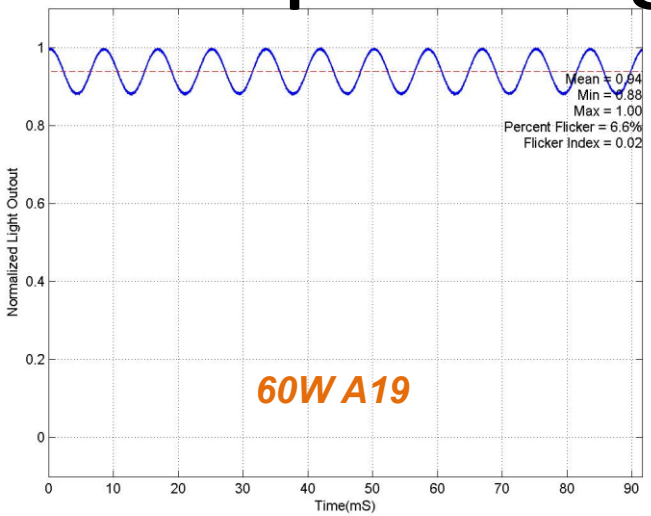
Commercial labels/marks
Certification of products & installations

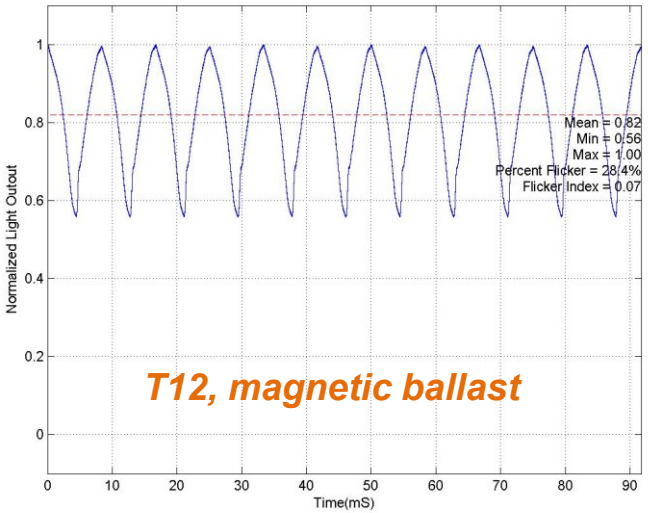
Publications industry associations
Position papers, white papers, guides

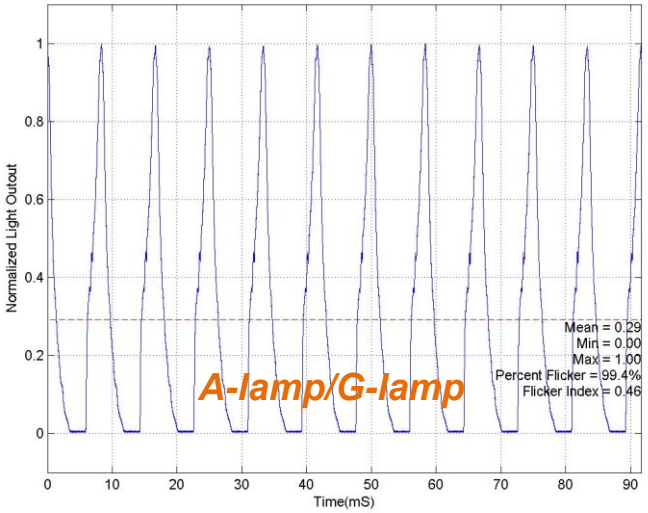
Why a workshop?

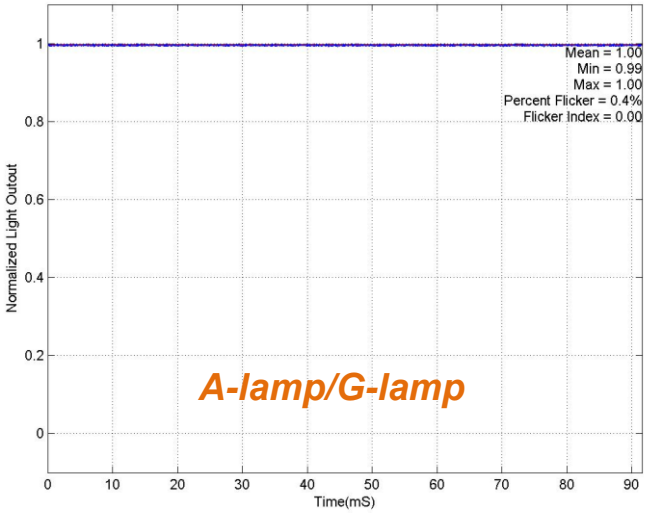
- To develop a roadmap of research, recommendations, and standards activities related to temporal light modulation from lighting systems
- The scope of the meeting was limited to developing the roadmap, establishing collaborations, and dividing the work amongst participants.
- The meeting was not intended to establish the content details for future standards documents.

Temporal Light Modulation









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Source: M. Poplawski, PNNL

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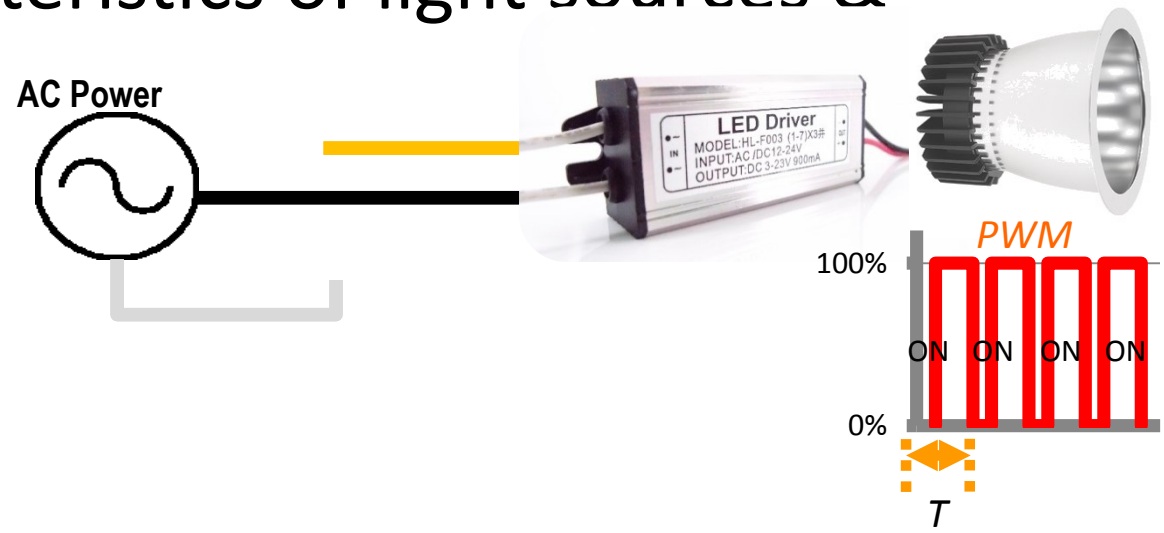
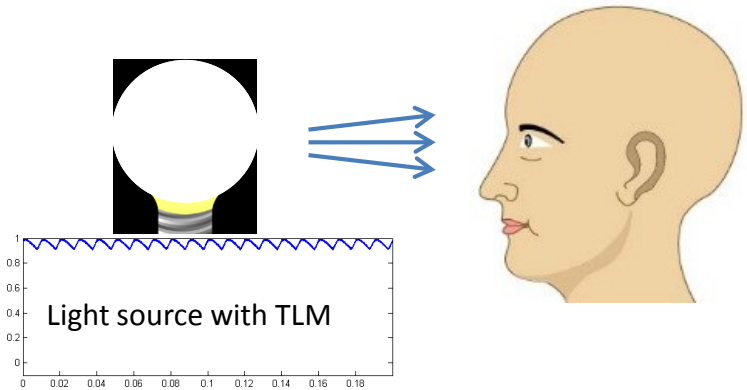
Why TLM of physical stimulus?

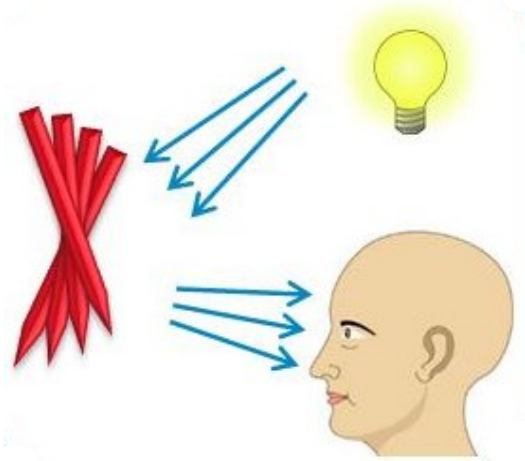
- AC mains supply
- Light source electronics (ballasts, drivers)
- Lighting system characteristics (e.g., dimming)
- Spatial characteristics of light sources & systems



What does it do?

- Effects on people and on equipment
  - Effects on equipment (e.g., interference with optical systems such as barcode readers and cameras) are out of scope.
  - **Effects on people were in scope for this workshop**.





What effects on people?

- Visual perception effects (temporal light artefacts, TLA):
  flicker, stroboscopic effect and phantom array
- Performance effects: eye movement changes, changes in visual performance, changes in cognitive task performance
- Neurobiological effects: headache, eyestrain, migraine, epilepsy, etc.

Temporal Light Artefact

- Temporal Light Artefact (TLA): Change in visual perception, induced by a light stimulus the luminance or spectral distribution of which fluctuates with time, for a human observer in a specified environment
  - Note 1 to entry: The change of visual perception is a result of comparing the visual perception of the environment lit by the modulated light to the visual perception of the same person in the same environment, when the environment is lit by non-modulated light.

or

or

Temporal Light Artefacts

Flicker

Perception of visual unsteadiness induced by a light stimulus whose luminance or spectral distribution fluctuates with time, for a static observer in a static environment.

~0-80Hz

No motion

Stroboscopic Effects

Change in motion perception induced by a light stimulus whose luminance or spectral distribution fluctuates with time, for a static observer in a non-static environment.

~80Hz-2kHz

Object motion

Phantom Array

Perception of a spatially extended series of light spots when making a *saccade* (image transition across the retina) across a light source that fluctuates with time

~80Hz-2kHz

Eye motion

What have researchers done?

- Flicker perception and stroboscopic effect have proposed metrics
- Spatial and temporal contrast sensitivity functions exist
- Evidence that ~100-120 Hz 35% modulation causes:
  - headache in susceptible individuals
  - disrupted eye movements
  - reduced visual performance

What have organizations done?

Definitions – some metrics

- CIE: TN 006:2016: “Visual Aspects of Time-Modulated Lighting Systems – Definitions and Measurement Models”. Definitions and measures for TLA (P_{st}^{LM} and SVM). These measures can predict whether people on average will perceive flicker and stroboscopic effect.

Measurement protocols:

- IEC: Measurement method for P_{st}^{LM} is available
- ENERGY STAR:
  - Flicker index/percent flicker reporting requirements in Lamps V2.0
  - proposal for ASSIST metric (predicts flicker perception)

Recommendations for criteria:

- IEEE: Publication of Std 1789: “Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers”. Discussion on potential health risks and recommendations for modulation frequencies.
- SAC: CQC 1601-2016 and CQC 31-465318-2016 certification criteria for table lamps and for lighting in schools, following the IEEE Std 1789-2015
- NEMA: Standard for Temporal Light Artifacts, coming soon in 2017.

What are the knowledge gaps?

- Phantom array – a metric to predict this
- Relationship between TLA phenomena and other cognitive & health effects
  - Can metrics that predict TLA also predict these other phenomena?
- Scaling up from short-term, small-scale viewing conditions to long-term, environmental viewing conditions

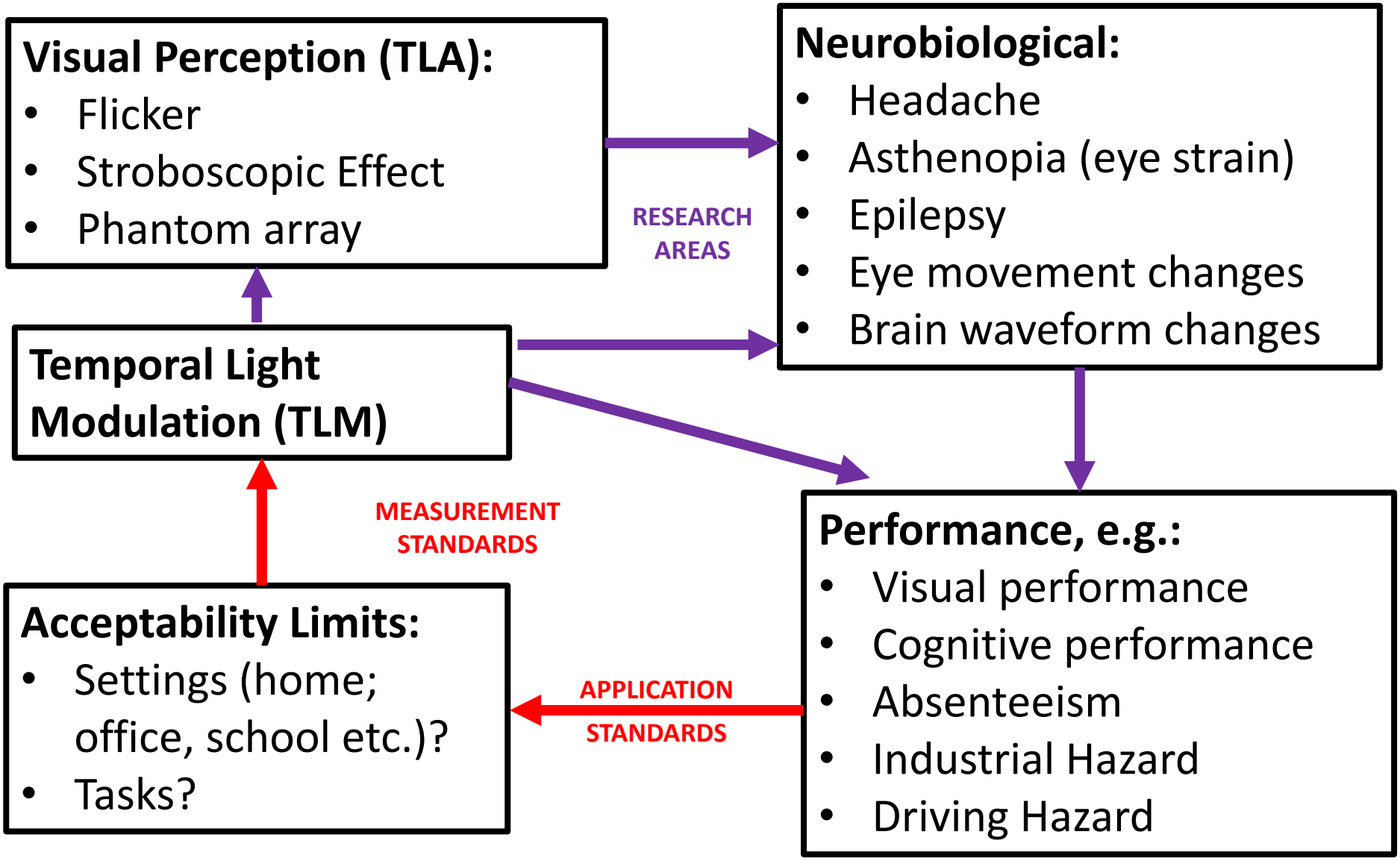
What more do we need to know?

- More about viewing context:
  - Waveform & duty cycle influence
  - Spectral (chromatic) variation
  - Adaptation luminance (higher luminance ↑ risk)
  - Contrast
  - Size of retinal area being stimulated
  - Distance to source and its location in the visual field (central stimulation ↑ risk)

Barriers to advancement

- Consistent TLM measurement protocol needed:
  - Report power spectrum (analogy to SPD)
  - Share data to calculate any metric
- Ethics challenges to studying adverse effects
- Replication and independent validation

What did we do?



How did we conclude?

- Part 4: Set priorities among the gaps (all)
- Part 5: Set out the roadmap:
  - What pieces do we need?
  - Who will do them?

The start of the roadmap…

- International standards are the goal
- Developed collaboratively, in a co-ordinated manner
- Based on solid evidence and open information sharing
- Existing activities continue, new activities will evolve from new friends working together

…***this is a work in progress…***

Next Steps

- A written report, reviewed by participants, published as a CIE Technical Note
  - ***in progress***
- Coming soon, subject to partner agreement:
  - CIE Research Forum for discussion & information sharing
  - New CIE TC on measurement protocols
  - Co-operative efforts to stimulate the needed research

More Information

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